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Financialized Commodities and Stock Indices Volatilities

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***Abstract**:*

We investigate the relationship between commodity returns and macroeconomic fluctuations. Using realized volatility at different series and different moving average windows in the eight financialized commodities and three stock indices (NASDAQ, DJIA and SP500), we find that the fluctuation of NASDAQ, DJIA and SP500 returns tend to be statistically significant in explaining the variation of volatilities of commodity returns.

This finding is strong for all eight financialized commodities and at different returns series. However, the directions on how the index volatility affect the commodity volatility are different. Higher realized volatility of NASDAQ return causes lower realized volatility of financialized commodity returns while higher realized volatility of SP500 return causes higher realized volatility of financialized commodity return.

DJIA has different directions in each series. Realizing that a lot of companies comprising NASDAQ and SP500 indices while only few companies comprising DJIA index, we conclude that our finding is consistent with the theory of well-diversified portfolio.

***Keywords**: Commodity markets, volatility, moving average, stock indices.*

***JEL Classification:** G11, G31**,** Q02.*

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1. Introduction

Recent literatures show that there is a financialization of commodity market. Basak and Pavlova (2016) document a substantial increase in investments of commodity markets in the recent decade. The sharp growth in commodity markets is also reported by Casassus and Dufresne (2005), Vivian and Wohar (2012) and Basu and Miffre (2013). Therefore, according to Stoll and Whaley (2010) and Tang and Xiong (2012), this commodity market financialization demonstrates that investors seriously consider the commodity as one of the alternative assets (Thalassinos and Dafnos, 2015).

There are recent studies investigating factor models of the commodity return. The studies include commodity markets and futures returns (Ahmed and Tsetanov, 2016; Berger and Uddin, 2016), commodity derivative and commodity related stock returns (Chiang *et al.*, 2015), and commodity and stock returns (Creti *et al.*, 2013). However, none of them explore the relationship between commodity and index volatilities. This question is essential because commodity return fluctuations are likely explained by macroeconomics fluctuations. The macroeconomics fluctuations are indicated by stock index return fluctuations (Thalassinos *et al.*, 2012; 2013; Grima *et al.*, 2017).

The relationship between macroeconomic variables and stock market prices have been intensively discussed by many finance scholars. For instance, Fama (1981; 1990), and Fama and French (1989) report that there is a significant relationship between macroeconomic variables and stock prices. A classic paper by Ferson and Harvey (1991), demonstrates a positive relationship between macroeconomic variables and stock prices. More recent works by Mukherjee and Naka (1995), Cheung and Ng (1998) and Humpe and Macmillan (2009) also find a significant relationship between stock prices and macroeconomic indicators. Therefore, we expect that the relationship between commodity and macroeconomic fluctuations also exists.

The main contribution of this paper is exploring the relationship between commodity returns fluctuations and macroeconomic fluctuations, as indicated in the stock index return fluctuations. Specifically, we do the investigation about the significance and direction of the relationship. The remainder of the paper is organized as follow: Section 2 reviews relevant studies about multi-factor returns in commodity markets; Section 3 discusses the method; Section 4 describes the data and discusses the empirical results; Section 5 concludes.

2. Literature Review

Multifactor commodity returns analysis has become recent important issues in the finance literature. Ahmed and Tsetanov (2016) examine the commodity futures excess returns using two factor models. They find weak evidence that the factor models can better explain the monthly excess returns. Furthermore, they also show that the commodity-based risk factors do not generate systematic economic value. A paper by Berger and Uddin (2016) investigates multiscale dependence analysis among equity

markets, commodity futures and uncertainty indexes. They demonstrate that there is a stronger dependence between the long-run trends of the asset classes. Another work by Chiang *et al.* (2015) estimates oil risk factors in the non-oil pricing models. They report that there is a degree of sensitivity from the oil to the oil industry. Unfortunately, none of them have analyzed how the multi factor commodity volatility is related to the macroeconomic changes (Thalassinos and Politis, 2011; Japparova and Rupeika-Apoga, 2017).

There are recent studies examining the relationship between commodity and stock market in the multi factor frameworks. For instance, Creti *et al.* (2013) explore the relationship between commodities and stocks price returns. They find that the correlations between commodity and stock markets are time-varying and high volatile. Another study by Nagayev *et al.* (2016) discusses the potential diversification benefits of commodities in the equity index portfolio. They also find that correlations between commodity markets and the index are time-varying and highly volatile. Thus, they conclude that the potential diversification benefits vary across different commodities. Olson *et al.* (2014) investigate the relationship between the energy and equity markets using a multivariate BEKK volatility model. They find a weak response from index volatility to energy price shocks. Their finding suggests that the energy index is not good for hedging. However, none of them discussed how the macroeconomic fluctuations affect the commodity volatility.

Stock market is a good pointer or predictor of the economy (Jareno and Loredan, 2016; Thalassinos *et al.*, 2015). A significant number trust that expansive abatements in stock costs are reflective of a future recession. The securities exchange concerning illustration about a pointer of monetary activity, however, does not come without thorough discussion. The solid budgetary development that emulated the 1987 securities exchange crash creates doubt about the stock market's predictive capability.

3. Method

Some literatures document the importance of using the realized volatility in commodity markets (Wang *et al.*, 2008; Souček and Todorova, 2013; Fonseca *et al.*, 2016). Therefore, we use the realized volatility in our models. One of widely-used methods is moving average (Hatchett *et al.*, 2009). The next question is what is the appropriate window of moving average in commodity markets. Hatchett *et al.* (2009) suggest 1 to 5 – year moving average in the commodity markets.

The moving average realized volatility of return can be expressed as follows:

$$VOL_t = \frac{1}{k-1} \sum_{i=1}^{k} (r_{t-i} - \bar{r})^2 \quad (1)$$

where $VOL_{,t}$ denotes the moving average realized volatility (standard deviation) of return at time t, k is the window of moving average (1 year, 2 years, 3 years, 4 years

and 5 years), r_{t-i} denotes the previous returns (from t-1 to t-k), and $\bar{r}$ is the average return during the window period (i.e. from t-1 to t-k).

We use three major stock indices of US market. The indices are NASDAQ, Dow Jones Industrial Average Index (DJIA) and Standard & Poor 500 (SP500). DJIA includes 30 blue chip companies measuring the execution of a portfolio comprising of one share of each company. SP500 is more comprehensive and representative than DJIA because it consists of 500 companies. NASDAQ is the most developed stock market with around 4,500 listed companies. Indeed, 479 of those companies are non-US companies. In recent years, 89 percent of all initial public offerings of shares in the US have been done through NASDAQ. Therefore, we argue that it is appropriate to examine the volatility of macroeconomic variables using those three major stock indices.

Our model investigating how the volatility of macroeconomic variables, as indicated in the volatility of market indices, affect the volatility of commodities is as follows:

$$VOL_{COM,t} = \alpha + \beta_1 * VOL_{NASDAQ,t} + \beta_2 * VOL_{DJIA,t} + \beta_3 * VOL_{SP500,t} + \varepsilon_t \quad (2)$$

where $VOL_{COM,t}$ denotes the realized volatility of return of a commodity at time t, $VOL_{NASDAQ,,t}$ is the realized volatility of return of NASDAQ index at time t, $VOL_{DJIA,t}$ is the realized volatility of return of Dow Jones index at time t, and $VOL_{SP500,t}$ is the realized volatility of return of SP500 index 3 at time t.

3. Empirical Analysis

Our sample includes: crude oil, natural gas, gold, silver, copper, corn, wheat and soybean. Those are the financial commodities that are discussed in recent literature (Plantier, 2012; Nakaso, 2011; Baker, 2015). We perform the daily, weekly and monthly analysis to obtain a robust finding since data availability dictates the time span for commodity markets (Narayan *et al.*, 2013). Furthermore, we also perform the analysis at different moving average windows, from 1 to 5 year(s) horizons as advised by Hatchett *et al.* (2009).

Our sample period is from January 1, 2000 to December 31, 2015. We start the sample period from early 2000 because commodity markets have entered the financialization era since 2000s (Rossi, 2012; Tang and Xiong, 2012). Thus, the 1-year window moving average uses data from January 1, 2001 to December 31, 2015, the 2-year window moving average uses data from January 1, 2002 to December 31, 2015, the 3-year window moving average uses data from January 1, 2003 to December 31, 2015, the 4-year window moving average uses data from January 1, 2004 to December 31, 2015 and the 5-year window moving average uses data from January 1, 2005 to December 31, 2015 for our model as expressed in equation (2).

Table 1. *Descriptive statistics of returns for eight financialized commodities and three stock indices on the daily series (Panel A), weekly series (Panel B) and monthly series (Panel C) from January 1, 2000 to December 31, 2015.*

Panel A: Daily series	**Oil**	**Gas**	**Gold**	**Silver**	**Copper**	**Corn**	**Wheat**	**Soybean**	**NASDAQ**	**DJIA**	**SP500**
Mean	0.01%	0.00%	0.03%	0.02%	0.02%	0.01%	0.01%	0.01%	0.02%	0.02%	0.02%
Standard Deviation	2.41%	4.25%	1.13%	1.93%	1.72%	1.91%	2.50%	2.77%	1.64%	1.16%	1.24%
Minimum	-17.09%	-56.95%	-10.16%	-12.98%	-10.36%	-12.11%	-22.59%	-80.55%	-9.67%	-7.87%	-9.03%
Maximum	16.41%	62.27%	6.87%	13.66%	11.73%	10.89%	13.87%	78.35%	14.17%	11.08%	11.58%
# of Observation	4,174	4,174	4,174	4,174	4,174	4,174	4,174	4,174	4,174	4,174	4,174
Panel B: Weekly series	**Oil**	**Gas**	**Gold**	**Silver**	**Copper**	**Corn**	**Wheat**	**Soybean**	**NASDAQ**	**DJIA**	**SP500**
Mean	0.04%	-0.01%	0.16%	0.12%	0.11%	0.08%	0.07%	0.06%	0.09%	0.08%	0.08%
Standard Deviation	5.54%	8.74%	2.55%	4.31%	3.55%	4.28%	5.15%	4.41%	3.59%	2.49%	2.63%
Minimum	-36.08%	-39.32%	-14.50%	-28.13%	-16.51%	-21.53%	-22.18%	-42.91%	-15.50%	-11.76%	-13.85%
Maximum	27.33%	73.33%	14.12%	18.92%	12.05%	16.00%	21.87%	38.41%	19.24%	13.99%	13.83%
# of Observation	835	835	835	835	835	835	835	835	835	835	835
Panel C: Monthly series	**Oil**	**Gas**	**Gold**	**Silver**	**Copper**	**Corn**	**Wheat**	**Soybean**	**NASDAQ**	**DJIA**	**SP500**
Mean	0.20%	0.03%	0.67%	0.51%	0.52%	0.34%	0.30%	0.25%	0.47%	0.08%	0.31%
Standard Deviation	9.78%	18.91%	4.94%	9.28%	7.97%	9.85%	11.52%	6.70%	7.24%	0.01%	4.80%
Minimum	-42.94%	-57.13%	-18.78%	-30.38%	-41.25%	-33.89%	-47.87%	-26.99%	-21.54%	0.07%	-16.77%
Maximum	27.34%	55.31%	12.12%	23.46%	23.12%	27.15%	32.84%	24.15%	23.18%	0.09%	15.73%
# of Observation	193	193	193	193	193	193	193	193	193	193	193

Table 1 reports the descriptive statistics of daily (Panel A), weekly (Panel B) and monthly (Panel C) returns for eight financialized commodities and three stock indices from January 1, 2000 to December 31, 2015. The descriptive statistics include the mean, standard deviation, minimum, maximum and the number of observation of each commodity or index.

We find that the average daily returns range from 0.00 percent for gas to 0.03 percent for gold, the average weekly returns range from negative 0.01 percent for gas to 0.16 percent for gold and the average monthly returns range from negative 0.03 percent for gas to 0.67 percent for gold. Overall, gas tends to generate the smallest average return while gold tends to generate the highest average return. We find that the volatilities of daily returns range from 1.13 percent for gold to 4.25 percent for gas, the average volatilities of weekly returns range from 2.49 percent for DJIA to 8.74 percent for gas and the average volatilities of monthly returns range from 0.01 percent for DJIA to 18.91 percent for gas. Overall, DJIA tends to have the least volatile return series while gas tends to have the most volatile return series. Then, we calculate moving average realized volatility for the returns series of those eight commodities and three stock indices at five different windows. After obtaining the realized volatility variables for the commodities and indices, we perform the regression equation (2) to investigate the relationship between financialized commodities and stock indices volatilities. Table 2 reports the regression results for the daily series, Table 3 reports the regression results for the weekly series and Table 4 reports the regression results for the monthly series.

According to Table 2, we find that the volatilities of NASDAQ, DJIA and SP500 daily returns tend to be statistically significant in explaining the variation of volatilities of

commodity daily returns. The result is strong for all eight financialized commodities. However, the directions, as shown in the beta coefficients, on how the index volatility affect the commodity volatility are different. The beta coefficients signs for NASDAQ and DJIA indices tend to be negative while the beta coefficients signs for SP500 index tend to be positive. These results indicate that higher realized volatilities of NASDAQ and DJIA daily returns cause lower realized volatilities of financialized commodities daily returns while higher realized volatilities of SP500 daily returns cause higher realized volatilities of financial commodities daily returns. Most of the explanatory powers range from 49 percent to 98 percent with exceptions of gas (in the 1-year window moving average) and soybean (in all windows moving average) commodities. This indicates that the economic model of equation (2) is sensible.

According to Table 3, we also find that the volatilities of NASDAQ, DJIA and SP500 weekly returns tend to be statistically significant in explaining the variation of volatilities of commodity weekly returns. The result is strong for all eight financialized commodities. However, the directions, as shown in the beta coefficients, on how the index volatility affect the commodity volatility are different. The beta coefficients signs for NASDAQ (all windows moving average) and DJIA (1-year and 2-year windows moving average) indices tend to be negative while the beta coefficients signs for DJIA (3-year, 4-year and 5-year windows moving average) and SP500 indices tend to be positive. These results indicate that higher realized volatilities of NASDAQ and short term horizon DJIA weekly returns cause lower realized volatilities of financialized commodities weekly returns while higher realized volatilities of long term horizon DJIA and SP500 weekly returns cause higher realized volatilities of financialized commodities weekly returns. Most of the explanatory powers range from 34 percent to 87 percent with exceptions (again) of gas (in the 1-year window moving average) and soybean (in all windows moving average) commodities. This also indicates that the economic model of equation (2) is sensible.

According to Table 4, we also find that the volatilities of NASDAQ, DJIA and SP500 monthly returns tend to be statistically significant in explaining the variation of volatilities of commodity monthly returns. The result is strong for all eight financial commodities. However, the directions, as shown in the beta coefficients, on how the index volatility affect the commodity volatility are different. The beta coefficients signs for NASDAQ index tend to be negative while the beta coefficients signs for DJIA and SP500 indices tend to be positive. These results indicate that higher realized volatilities of NASDAQ monthly returns cause lower realized volatilities of financialized commodities monthly returns while higher realized volatilities of DJIA and SP500 monthly returns cause higher realized volatilities of financialized commodities monthly returns. Most of the explanatory powers range from 42 percent to 95 percent with exceptions of gas, silver, corn, and wheat (in the 1-year window moving average) and soybean (in the 1-year and 2-year windows moving average) commodities. This is another justification whether the economic model in equation (2) is sensible.

Table 2. *Results of regression equation (2) for eight commodities at five different moving average windows using daily series. The asterisk indicates a significance of the coefficient at the *) 10 percent significance level, **) 5 percent significance level, ***) 1 percent significance level*

Daily series	Equation (2): $VOL_{COM,t} = \alpha + \beta 1\ VOL_{NASDAQ,t} + \beta 2\ VOL_{DJIA,t} + \beta 3\ VOL_{SP500,t} + \varepsilon_t$							
1-year moving average window								
Commodity	**Oil**	**Gas**	**Gold**	**Silver**	**Copper**	**Corn**	**Wheat**	**Soybean**
α	0.0090 ***)	0.0358 ***)	0.0081 ***)	0.0170 ***)	0.0123 ***)	0.0156 ***)	0.0188 ***)	0.0218 ***)
	(45.69)	(62.78)	(87.27)	(105.73)	(70.34)	(134.86)	(96.09)	(34.55)
β1	0.1861 ***)	0.5637 ***)	-0.3725 ***)	-0.9047 ***)	-0.5917 ***)	-0.4808 ***)	-0.7867 ***)	-0.6417 ***)
	(10.06)	(10.55)	(-42.93)	(-59.93)	(-36.24)	(-44.32)	(-42.91)	(-10.84)
β2	2.4779 ***)	8.4958 ***)	-0.8082 ***)	-3.0028 ***)	-2.8700 ***)	-2.6660 ***)	-2.8579 ***)	3.1134 ***)
	(16.73)	(19.85)	(-11.63)	(-24.83)	(-21.95)	(-30.68)	(-19.46)	(6.57)
β3	-1.3520 ***)	-8.3898 ***)	1.4800 ***)	4.1093 ***)	3.8053 ***)	3.4045 ***)	4.1838 ***)	-2.2054 ***)
	(-10.02)	(-21.51)	(23.37)	(37.29)	(31.93)	(43.00)	(31.26)	(-5.11)
Adj R-squared	0.5926	0.1189	0.5388	0.5892	0.4935	0.6080	0.5590	0.0360
2-year moving average window								
Commodity	**Oil**	**Gas**	**Gold**	**Silver**	**Copper**	**Corn**	**Wheat**	**Soybean**
α	0.0083 ***)	0.0338 ***)	0.0094 ***)	0.0196 ***)	0.0135 ***)	0.0157 ***)	0.0172 ***)	0.0228 ***)
	(56.27)	(114.93)	(156.85)	(228.94)	(80.69)	(199.91)	(128.62)	(40.97)
β1	0.0803 ***)	-0.0719 *)	-0.3838 ***)	-0.7782 ***)	-0.6231 ***)	-0.4236 ***)	-0.8480 ***)	-1.2747 ***)
	(4.04)	(-1.82)	(-47.72)	(-67.74)	(-27.65)	(-40.13)	(-47.25)	(-17.07)
β2	3.0249 ***)	18.0059 ***)	-1.6320 ***)	-5.7245 ***)	-3.7499 ***)	-4.2023 ***)	-3.8155 ***)	7.3311 ***)
	(18.54)	(55.51)	(-24.71)	(-60.69)	(-20.27)	(-48.49)	(-25.90)	(11.96)
β3	-1.6889 ***)	-16.1175 ***)	2.1689 ***)	6.3163 ***)	4.5820 ***)	4.7695 ***)	5.2906 ***)	-5.5426 ***)
	(-12.45)	(-59.76)	(39.50)	(80.52)	(29.78)	(66.19)	(43.18)	(-10.87)
Adj R-squared	0.7567	0.5676	0.7706	0.8747	0.5921	0.8459	0.8301	0.0816
3-year moving average window								
Commodity	**Oil**	**Gas**	**Gold**	**Silver**	**Copper**	**Corn**	**Wheat**	**Soybean**
α	0.0077 ***)	0.0305 ***)	0.0095 ***)	0.0196 ***)	0.0127 ***)	0.0150 ***)	0.0162 ***)	0.0238 ***)
	(56.95)	(130.96)	(169.30)	(258.11)	(72.02)	(195.23)	(126.67)	(44.58)
β1	-0.4199 ***)	0.1991 ***)	-0.4903 ***)	-1.0374 ***)	-1.1648 ***)	-0.6757 ***)	-1.0912 ***)	-1.7145 ***)
	(-17.30)	(4.76)	(-48.69)	(-75.93)	(-36.89)	(-48.99)	(-47.39)	(-17.90)
β2	6.4884 ***)	18.2027 ***)	-1.0361 ***)	-4.0145 ***)	0.3086	-2.2280 ***)	-1.5223 ***)	8.0570 ***)
	(36.20)	(58.94)	(-13.93)	(-39.78)	(1.32)	(-21.87)	(-8.95)	(11.39)
β3	-4.2817 ***)	-16.3294 ***)	1.7268 ***)	5.0195 ***)	1.5134 ***)	3.2800 ***)	3.5131 ***)	-5.8232 ***)
	(-30.29)	(-67.04)	(29.44)	(63.07)	(8.23)	(40.82)	(26.19)	(-10.44)
Adj R-squared	0.8134	0.7630	0.8375	0.9238	0.6573	0.8906	0.8756	0.1104
4-year moving average window								
Commodity	**Oil**	**Gas**	**Gold**	**Silver**	**Copper**	**Corn**	**Wheat**	**Soybean**
α	0.0070 ***)	0.0314 ***)	0.0093 ***)	0.0191 ***)	-1.2162 ***)	-0.0147 ***)	-0.0158 ***)	-0.0260 ***)
	(55.30)	(162.56)	(165.43)	(258.44)	(-63.28)	(-177.86)	(-121.65)	(-45.86)
β1	-0.3229 ***)	0.3262 ***)	-0.4785 ***)	-0.9891 ***)	1.2162 ***)	0.6259 ***)	0.9883 ***)	0.8555 ***)
	(-15.87)	(10.46)	(-52.76)	(-83.03)	(40.41)	(46.82)	(47.16)	(9.33)
β2	6.6833 ***)	16.6903 ***)	-0.9627 ***)	-3.1741 ***)	-2.1172 ***)	1.9338 ***)	1.2687 ***)	-0.2091
	(44.25)	(72.12)	(-14.30)	(-35.89)	(-9.48)	(19.49)	(8.15)	(-0.31)
β3	-4.5063 ***)	-15.1234 ***)	1.6598 ***)	4.2364 ***)	0.0179	-2.9738 ***)	-3.2030 ***)	-0.3044
	(-37.90)	(-83.02)	(31.32)	(60.86)	(0.10)	(-38.07)	(-26.15)	(-0.57)
Adj R-squared	0.8582	0.8520	0.8829	0.9423	0.6961	0.9048	0.9031	0.0770
5-year moving average window								
Commodity	**Oil**	**Gas**	**Gold**	**Silver**	**Copper**	**Corn**	**Wheat**	**Soybean**
α	0.0057 ***)	0.0343 ***)	0.0086 ***)	0.0176 ***)	0.0092 ***)	0.0140 ***)	0.0157 ***)	0.0356 ***)
	(47.73)	(124.32)	(195.80)	(366.72)	(50.81)	(176.55)	(114.49)	(57.86)
β1	-0.1881 ***)	0.1990 ***)	-0.5548 ***)	-0.9754 ***)	-1.3028 ***)	-0.6418 ***)	-1.0005 ***)	-0.0183
	(-11.38)	(5.20)	(-91.00)	(-146.73)	(-52.14)	(-58.29)	(-52.75)	(-0.22)
β2	6.4275 ***)	16.0172 ***)	0.0010	-1.9220 ***)	4.7038 ***)	-1.1189 ***)	-0.6614 ***)	-10.1579 ***)
	(51.62)	(55.59)	(0.02)	(-38.38)	(25.00)	(-13.49)	(-4.63)	(-15.84)
β3	-4.3161 ***)	-14.5724 ***)	0.9045 ***)	3.1755 ***)	-2.0979 ***)	2.2930 ***)	2.6674 ***)	8.2179 ***)
	(-44.34)	(-64.69)	(25.20)	(81.12)	(-14.26)	(35.37)	(23.88)	(16.39)
Adj R-squared	0.8979	0.8060	0.9541	0.9836	0.8026	0.9425	0.9281	0.2264

Table 3. *Results of regression equation (2) for eight commodities at five different moving average windows using weekly series. The asterisk indicates a significance of the coefficient at the *) 10 percent significance level, **) 5 percent significance level, ***) 1 percent significance level*

Weekly series	**Equation (2): $VOL_{COM,t} = \alpha + \beta 1\ VOL_{NASDAQ,t} + \beta 2\ VOL_{DJIA,t} + \beta 3\ VOL_{SP500,t} + \varepsilon_t$**							
1-year moving average window								
Commodity	**Oil**	**Gas**	**Gold**	**Silver**	**Copper**	**Corn**	**Wheat**	**Soybean**
α	0.0102 ***)	0.0686 ***)	0.0193 ***)	0.0405 ***)	0.0285 ***)	0.0375 ***)	0.0386 ***)	0.0371 ***)
	(7.74)	(29.56)	(33.02)	(39.78)	(29.71)	(66.59)	(38.14)	(28.17)
β1	0.4616 ***)	0.4492 ***)	-0.2683 ***)	-0.7768 ***)	-0.3836 ***)	-0.3906 ***)	-0.4397 ***)	-0.1387 ***)
	(9.41)	(5.17)	(-12.27)	(-20.37)	(-10.71)	(-18.55)	(-11.62)	(-2.82)
β2	0.9039 ***)	7.2931 ***)	-0.7370 ***)	-3.6508 ***)	-2.0052 ***)	-2.0422 ***)	-1.5489 ***)	-0.3899
	(2.92)	(13.30)	(-5.33)	(-15.15)	(-8.86)	(-15.34)	(-6.48)	(-1.25)
β3	0.2196	-6.8681 ***)	1.2775 ***)	4.5341 ***)	2.6395 ***)	2.6629 ***)	2.5410 ***)	0.6127 **)
	(0.77)	(-13.67)	(10.09)	(20.54)	(12.73)	(21.84)	(11.60)	(2.15)
Adj R-squared	0.6136	0.2014	0.3937	0.5242	0.3442	0.5992	0.4497	0.0187
2-year moving average window								
Commodity	**Oil**	**Gas**	**Gold**	**Silver**	**Copper**	**Corn**	**Wheat**	**Soybean**
α	0.0065 ***)	0.0702 ***)	0.0216 ***)	0.0444 ***)	0.0283 ***)	0.0378 ***)	0.0346 ***)	0.0345 ***)
	(5.86)	(49.12)	(44.53)	(54.41)	(28.00)	(71.46)	(37.08)	(35.07)
β1	0.4684 ***)	-0.0440	-0.3532 ***)	-0.7562 ***)	-0.4382 ***)	-0.4687 ***)	-0.6030 ***)	-0.2156 ***)
	(8.48)	(-0.61)	(-14.53)	(-18.48)	(-8.65)	(-17.69)	(-12.89)	(-4.36)
β2	1.3855 ***)	9.3153 ***)	-0.5916 ***)	-3.7097 ***)	-1.7232 ***)	-1.7943 ***)	-0.7490 ***)	0.6177 **)
	(5.05)	(26.17)	(-4.90)	(-18.24)	(-6.84)	(-13.62)	(-3.22)	(2.52)
β3	-0.0941	-8.1297 ***)	1.1687 ***)	4.4447 ***)	2.4687 ***)	2.5190 ***)	2.1242 ***)	-0.1775
	(-0.41)	(-27.46)	(11.63)	(26.28)	(11.79)	(23.00)	(10.99)	(-0.87)
Adj R-squared	0.7329	0.5211	0.4797	0.6503	0.3697	0.6766	0.5794	0.0487
3-year moving average window								
Commodity	**Oil**	**Gas**	**Gold**	**Silver**	**Copper**	**Corn**	**Wheat**	**Soybean**
α	0.0035 ***)	0.0660 ***)	0.0218 ***)	0.0431 ***)	0.0251 ***)	0.0353 ***)	0.0306 ***)	0.0341 ***)
	(3.36)	(57.55)	(47.72)	(53.57)	(23.89)	(66.79)	(33.44)	(40.94)
β1	-0.4260 ***)	0.0336	-0.5200 ***)	-1.1861 ***)	-1.0546 ***)	-0.7313 ***)	-1.0765 ***)	-0.6512 ***)
	(-5.58)	(0.40)	(-15.49)	(-20.07)	(-13.64)	(-18.83)	(-16.00)	(-10.66)
β2	4.3451 ***)	9.0337 ***)	-0.1060	-1.7588 ***)	0.9106 ***)	-0.7586 ***)	1.1075 ***)	2.2094 ***)
	(14.10)	(26.57)	(-0.78)	(-7.38)	(2.92)	(-4.84)	(4.08)	(8.96)
β3	-1.6886 ***)	-7.7645 ***)	0.9061 ***)	3.1868 ***)	0.8698 ***)	1.9540 ***)	1.0966 ***)	-1.1417 ***)
	(-7.66)	(-31.90)	(9.34)	(18.68)	(3.90)	(17.42)	(5.65)	(-6.47)
Adj R-squared	0.7859	0.6852	0.5663	0.7113	0.4539	0.7514	0.6692	0.1608
4-year moving average window								
Commodity	**Oil**	**Gas**	**Gold**	**Silver**	**Copper**	**Corn**	**Wheat**	**Soybean**
α	-0.0007 ***)	0.0663 ***)	0.0212 ***)	0.0419 ***)	0.0236 ***)	0.0339 ***)	0.0276 ***)	0.0348 ***)
	(-0.69)	(64.20)	(41.39)	(52.35)	(21.18)	(56.83)	(29.68)	(40.02)
β1	-0.3526 ***)	0.0670	-0.4993 ***)	-1.2056 ***)	-1.1657 ***)	-0.7464 ***)	-1.0161 ***)	-0.2233 ***)
	(-5.51)	(1.00)	(-15.08)	(-23.31)	(-16.18)	(-19.38)	(-16.93)	(-3.97)
β2	4.6122 ***)	8.5810 ***)	-0.1420	-0.8003 ***)	2.1811 ***)	-0.3043 *)	1.2593 ***)	0.7902 ***)
	(17.70)	(31.55)	(-1.05)	(-3.80)	(7.43)	(-1.94)	(5.15)	(3.45)
β3	-1.8481 ***)	-7.3637 ***)	0.9406 ***)	2.3799 ***)	-0.0990	1.6068 ***)	1.0101 ***)	-0.3459 **)
	(-10.04)	(-38.34)	(9.87)	(15.99)	(-0.48)	(14.50)	(5.85)	(-2.14)
Adj R-squared	0.8419	0.7771	0.6289	0.7666	0.5191	0.7804	0.7556	0.0476
5-year moving average window								
Commodity	**Oil**	**Gas**	**Gold**	**Silver**	**Copper**	**Corn**	**Wheat**	**Soybean**
α	-0.0059 ***)	0.0669 ***)	0.0183 ***)	0.0363 ***)	0.0174 ***)	0.0320 ***)	0.0265 ***)	0.0390 ***)
	(-5.63)	(50.17)	(37.48)	(48.50)	(15.23)	(53.12)	(28.90)	(43.71)
β1	-0.1316 **)	-0.2639 ***)	-0.6522 ***)	-1.1697 ***)	-1.1689 ***)	-0.7437 ***)	-0.9440 ***)	0.0818 *)
	(-2.37)	(-3.74)	(-25.27)	(-29.52)	(-19.39)	(-23.35)	(-19.46)	(1.73)
β2	4.1181 ***)	9.8498 ***)	0.7312	0.0084	3.1130 ***)	-0.0607	1.0666 ***)	-0.9981 ***)
	(17.36)	(32.67)	(6.63)	(0.05)	(12.08)	(-0.45)	(5.14)	(-4.95)
β3	-1.4344 ***)	-8.1689 ***)	0.4146 ***)	1.7966 ***)	-0.7149 ***)	1.4526 ***)	1.1602 ***)	0.8105 ***)
	(-8.76)	(-39.25)	(5.44)	(15.36)	(-4.02)	(15.46)	(8.10)	(5.82)
Adj R-squared	0.8686	0.7844	0.7950	0.8648	0.6579	0.8615	0.8381	0.0624

Table 4. *Results of regression equation (2) for eight commodities at five different moving average windows using monthly series. The asterisk indicates a significance of the coefficient at the *) 10 percent significance level, **) 5 percent significance level, ***) 1 percent significance level*

Monthly series	**Equation (3): $VOL_{COM,t} = \alpha + \beta 1\ VOL_{NASDAQ,t} + \beta 2\ VOL_{DJIA,t} + \beta 3\ VOL_{SP500,t} + \varepsilon_t$**							
1-year moving average window								
Commodity	**Oil**	**Gas**	**Gold**	**Silver**	**Copper**	**Corn**	**Wheat**	**Soybean**
α	0.0159 *)	0.0517 *)	0.0299 ***)	0.1286 ***)	0.0266 **)	0.0710 ***)	0.0700 ***)	0.0485 ***)
	(1.75)	(1.90)	(5.52)	(10.06)	(2.45)	(5.86)	(3.36)	(4.76)
β1	-0.0304	1.6127 ***)	-0.4109 ***)	-0.7664 ***)	-0.6060 ***)	-0.5517 ***)	-0.8828 ***)	0.0456
	(-0.47)	(8.37)	(-10.68)	(-8.45)	(-7.87)	(-6.41)	(-5.97)	(0.63)
β2	816.85 ***)	2,595.86 ***)	178.42	-957.29 ***)	574.34 **)	444.45	478.18	626.65 ***)
	(3.91)	(4.16)	(1.43)	(-3.26)	(2.30)	(1.60)	(1.00)	(2.67)
β3	1.0286 ***)	-1.8102 ***)	0.8294 ***)	1.1329 ***)	1.4146 ***)	0.9431 ***)	1.6968 ***)	-0.2906 ***)
	(10.48)	(-6.17)	(14.16)	(8.21)	(12.07)	(7.20)	(7.53)	(-2.64)
Adj R-squared	0.5716	0.3721	0.5242	0.3684	0.4470	0.2228	0.2315	0.0794
2-year moving average window								
Commodity	**Oil**	**Gas**	**Gold**	**Silver**	**Copper**	**Corn**	**Wheat**	**Soybean**
α	0.0063	0.0737 ***)	0.0386 ***)	0.1725 ***)	0.0263 **)	0.0915 ***)	0.0099	0.0459 ***)
	(0.73)	(2.91)	(9.66)	(18.56)	(2.10)	(8.62)	(0.50)	(4.26)
β1	-0.1219 **)	1.7450 ***)	-0.4442 ***)	-0.7273 ***)	-0.6032 ***)	-0.7472 ***)	-1.2056 ***)	-0.0821
	(-2.26)	(10.90)	(-17.57)	(-12.37)	(-7.59)	(-11.13)	(-9.67)	(-1.20)
β2	1,051.56 ***)	2,226.37 ***)	6.87	-1,894.83 ***)	548.62 *)	79.57	1,506.09 ***)	817.29 ***)
	(5.22)	(3.73)	(0.07)	(-8.64)	(1.85)	(0.32)	(3.24)	(3.21)
β3	1.1645	-1.9539 ***)	0.8488 ***)	1.0106 ***)	1.4963 ***)	1.1027 ***)	2.5097 ***)	-0.1820 *)
	(15.58)	(-8.81)	(24.23)	(12.41)	(13.59)	(11.85)	(14.53)	(-1.93)
Adj R-squared	0.7332	0.5326	0.7972	0.7013	0.5480	0.5040	0.5608	0.1458
3-year moving average window								
Commodity	**Oil**	**Gas**	**Gold**	**Silver**	**Copper**	**Corn**	**Wheat**	**Soybean**
α	-0.0139 *)	0.0694 **)	0.0396 ***)	0.1616 ***)	0.0035	0.0614 ***)	-0.0271	0.0312 ***)
	(-1.83)	(2.58)	(10.73)	(19.21)	(0.24)	(7.84)	(-1.26)	(3.23)
β1	-0.2780 ***)	1.6402 ***)	-0.4518 ***)	-0.8612 ***)	-0.7561 ***)	-0.9927 ***)	-1.5532 ***)	-0.1786 ***)
	(-5.56)	(9.25)	(-18.58)	(-15.52)	(-7.94)	(-19.25)	(-10.96)	(-2.81)
β2	1,670.46 ***)	2,213.45 ***)	21.17	-1,520.02 ***)	1,193.65 ***)	876.49 ***)	2,396.40 ***)	1,347.94 ***)
	(9.03)	(3.37)	(0.24)	(-7.40)	(3.38)	(4.59)	(4.57)	(5.72)
β3	1.2627 ***)	-1.6669 ***)	0.8228 ***)	1.1092 ***)	1.6536 ***)	1.3817 ***)	2.9618 ***)	-0.1740 **)
	(20.54)	(-7.64)	(27.50)	(16.25)	(14.11)	(21.77)	(16.99)	(-2.22)
Adj R-squared	0.8395	0.5901	0.8804	0.8403	0.6219	0.7963	0.6872	0.4159
4-year moving average window								
Commodity	**Oil**	**Gas**	**Gold**	**Silver**	**Copper**	**Corn**	**Wheat**	**Soybean**
α	-0.0389 ***)	-0.0660 **)	0.0384 ***)	0.1477 ***)	-0.0475 ***)	0.0591 ***)	-0.0107	0.0614 ***)
	(-4.98)	(-2.28)	(10.23)	(15.90)	(-3.00)	(7.55)	(-0.43)	(8.85)
β1	-0.4199 ***)	0.5837 ***)	-0.4395 ***)	-0.7440 ***)	-0.9565 ***)	-0.8644 ***)	-1.5712 ***)	0.2021 ***)
	(-8.19)	(3.08)	(-17.84)	(-12.19)	(-9.20)	(-16.81)	(-9.68)	(4.44)
β2	2,305.13 ***)	5,771.09 ***)	48.94	-1,205.28 ***)	2,485.29 ***)	918.74 ***)	2,011.71 ***)	551.27 ***)
	(11.98)	(8.11)	(0.53)	(-5.26)	(6.37)	(4.76)	(3.30)	(3.22)
β3	1.4170 ***)	-0.4954 **)	0.8077 ***)	1.0114 ***)	1.8962 ***)	1.2380 ***)	2.9663 ***)	-0.5991 **)
	(23.89)	(-2.26)	(28.36)	(14.34)	(15.78)	(20.83)	(15.80)	(-11.38)
Adj R-squared	0.8843	0.6490	0.9231	0.8511	0.7033	0.8280	0.7413	0.7561
5-year moving average window								
Commodity	**Oil**	**Gas**	**Gold**	**Silver**	**Copper**	**Corn**	**Wheat**	**Soybean**
α	-0.0591 ***)	-0.2934 ***)	0.0584 ***)	0.1710 ***)	-0.1313 ***)	0.0770 ***)	-0.0126	0.1021 ***)
	(-5.32)	(-9.88)	(14.99)	(22.87)	(-7.53)	(6.83)	(-0.45)	(14.18)
β1	-0.3070 **)	-0.1568	-0.3484 ***)	-0.5525 ***)	-1.1027 ***)	-0.6394 ***)	-1.6128 ***)	0.3814 ***)
	(-5.75)	(-1.10)	(-18.60)	(-15.38)	(-13.17)	(-11.80)	(-11.90)	(11.02)
β2	2,561.13 ***)	10,888.58 ***)	-444.80 ***)	-1,810.17 ***)	4,259.03 ***)	369.46	2,117.69 ***)	-437.46 ***)
	(10.09)	(16.04)	(-4.99)	(-10.59)	(10.69)	(1.43)	(3.28)	(-2.66)
β3	1.4507 ***)	0.7790 ***)	0.6901 ***)	0.8123 ***)	2.2914 ***)	1.0426 ***)	2.9689 ***)	-0.8351 ***)
	(20.54)	(4.12)	(27.83)	(17.08)	(20.68)	(14.53)	(16.55)	(-18.23)
Adj R-squared	0.8660	0.8072	0.9592	0.9434	0.8104	0.8057	0.8172	0.8578

4. Conclusion

The paper investigates the relationship between commodity returns fluctuations and macroeconomic fluctuations. The macroeconomic fluctuations are indicated in the stock index return fluctuations. Using realized volatility at different series and different moving average windows in the eight financialized commodities, we investigate the significance and direction of the relationship.

We find that the fluctuations of NASDAQ, DJIA and SP500 returns tend to be statistically significant in explaining the variations of volatilities of commodity returns. This finding is strong for all eight financialized commodities and at daily, weekly and monthly returns series. However, the directions on how the index volatility affect the commodity volatility are different. Higher realized volatility of NASDAQ return causes lower realized volatility of financialized commodity return while higher realized volatility of SP500 return causes higher realized volatility of financialized commodity return. DJIA has different directions in each series. Higher realized volatility of DJIA return causes lower realized volatility of financialized commodity return in the daily series while higher realized volatility of DJIA return causes higher realized volatility of financialized commodity return in the monthly series. In the weekly series, higher realized volatilities of short term horizon DJIA returns cause lower realized volatilities of financialized commodities returns while higher realized volatilities of long term horizon DJIA returns cause higher realized volatilities of financialized commodities returns.

The different results of volatility of DJIA return variable seem due to relatively few companies consisting DJIA index. On the other hand, there are a lot of companies consisting both NASDAQ and SP500 indices so that we obtain consistent results of volatilities of NASDAQ and SP500 variables. This result is consistent with portfolio theory stating that more well-diversified portfolio will generate more stable (i.e. less volatile) return because the idiosyncratic risks have been eliminated.

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